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**FINAL TECHNICAL REPORT**  
on  
**AASERT RESEARCH GRANT NO: F49620-93-1-0515**  
**Millimeter Wave Source using a Phase Matched Non-Linear**  
**Multiple Quantum Well Optical Guide**

by  
Kang L. Wang, P.I.  
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UCLA-EE Dept.

This research has been aimed at investigating new means of microwave and millimeter wave generation using a nonlinear optical waveguide structure. Since our last report, the research has been focused on the approach of using a single Ti-sapphire laser to produce separate beams which are shifted slightly in frequency by the use of very narrow bandpass filters. The Ti-sapphire laser produces extremely short pulses in the 200 fs range, which by Fourier transform have a fairly broad frequency spectrum. After passing the output beam through a beamsplitter, the beams were filtered to produce two signals with wavelengths approximately 10 nm apart. With a fundamental output signal at 900 nm, this produces a difference frequency signal of approximately 81  $\mu$ m. The two beams were focussed into a waveguide structure which was polished and beveled at 45 degrees at the input edge in order to maximize the E-field components which are perpendicular to the quantum well structure. The optical pump wave was trapped within the channel by sandwiching the Quantum well structure between layers with lower indexes of refraction. In this manner, the pump waves travel the length of the waveguide structure with approximately 50 percent of the polarization in the proper orientation. The output wave is normal to the waveguide structure and cannot be confined by the small dimensions of the channel. In future work, the top and bottom structures of the sample could be optimized to form a cavity for the output wave to enhance the output coherence and minimize its divergence. The principal difficulty with this research has continued to be the lack of detectors in this frequency spectrum. Evidence of the output signal has been seen on the available instruments, but the data is thus far difficult to reproduce and analyze. In order to optimize the alignment of the input beams and to test other nonlinear properties of the quantum well structure, sum frequency generation was studied since this produces signals which are easily detectable by the available photodetectors and optics. Although there are some slight variations in the physics of the two different processes, a good portion of the work required to produce difference frequency signals had to be completed in order to produce sum frequency waves. The next step is to acquire an adequate detector and push into the millimeter regime. Currently, it is felt that a bolometer would be the best means of detecting these signals although recent advances in long wavelength photo detectors are encouraging for future research in the quasi-optical portion of the spectrum.

The student involved in this research is making satisfactory progress towards the completion of his Ph.D. It is expected that this student will complete his studies in early 1998. One previous student involved in the initial phases of this research completed his Ph.D. in 1996.

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